Systematic behaviour of the width of the mass-distribution for ^{48}Ti+^{144,154}Sm systems

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Introduction

Measurements of fission fragment angular distribution (FFAD), mass-distribution (MD) and mass-energy correlation helps in distinguishing FF and QF processes [1]. The various factors that influence the width of the MD are mass-asymmetry, deformation of interacting nuclei, collision energy, fissility and the charge product $Z_P \times Z_T$ of the interacting partners. Any sudden change in the width of the MD would indicate departure from full equilibration. That means, the explicit dependence of QF on various above mentioned parameters can provide more insight to the fission dynamics. With this motivation, we have performed an experiment for ^{192,202}Po compound nuclei populated by ^{48}Ti+^{144,154}Sm reactions in the laboratary energy range varying between 246-198 MeV using the scattering chamber of National Array of Neutron Detectors (NAND) facility at Inter University Accelerator Centre, New Delhi. In the present work we have extracted the mass-widths of the fission fragments for ^{48}Ti+^{144,154}Sm systems. We have also included the highly assymmetric system ^{16}O+^{186}W [2] forming nearby compound nucleus (CN) (Z_{CN}=82) along with symmetric reactions ^{48}Ca+^{154}Sm [2] and ^{48}Ti+^{208}Pb [3] for comparison, for which experimental data is already available in the literature. We have also performed the scission point model calculations for these systems in order to establish dependence of mass width on various observables like excitation energy, fissility, E_{CM}/V_B. The details of the experimental set up is given in ref [4].

Data Analysis and Results

The two-body kinematics method have been used to obtain the fragment masses and velocities [5]. The extracted width of the MD for ^{48}Ti+^{144}Sm system are 30 and 26 a.m.u at E^* = 72 and 50 MeV respectively. For ^{48}Ti+^{154}Sm the extracted width of the MD at E^* = 72 and 95 MeV are 26 and 29 a.m.u respectively [4].

Scission point model calculations

The saddle or the scission point of the fissioning nucleus plays an important role in determining the properties of fission fragments. Scission point model assumes that the mass-equilibration is attained near the scission. According to this model, a quadratic mass-asymmetric potential [6] is used to calculate the mass-width. Using this prescription the standard deviation of the MD is estimated as:

$$\sigma_M = \sqrt{T_{Sci}/k} \quad (1)$$

T_{Sci} is the scission point temperature [6]. The predictions from the scission point model along with experimental mass-width is depicted in Fig. 1. From the figure it is clear that even though the experimental mass-width are

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in consistent with the scission point model predictions for ^{16}O+^{186}W system, wheras as experimental mass-widths for ^{48}Ti+^{144,154}Sm reaction are overestimated. This increase in the value of mass-width may be a signature of the onset of QF process in these systems.

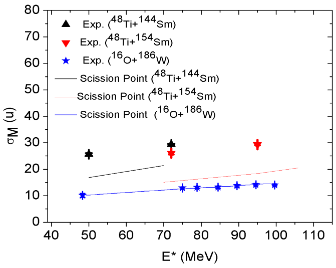

FIG. 1: Mass-width as a function of excitation energy of the different compound nuclei. Solid line indicates the scission point model results

Dependence on E_{CM}/V_B and fissility

The mass-widths for ^{48}Ti+^{144,154}Sm systems are plotted as a function of E_{CM}/V_B in Fig. 2 (upper panel). Here, we have also included the system ^{48}Ti+^{208}Pb [3] for having a close look at behaviour of spherical target (^{208}Pb) on mass-widths. From Fig. 2 (upper panel) one can infer that for spherical targets (^{144}Sm and ^{208}Pb), the mass-widths uniformly increase as the beam energy increases from below (E_{CM}/V_B=0.96) to well above the Coloumb barrier energies (E_{CM}/V_B=1.11). Fig. 2 (lower panel) shows the variation of experimental mass-widths as a function of fissility of the CN at below (E_{CM}/V_B=0.96) and well above (E_{CM}/V_B=1.11) the Coulomb barrier energies. The mass-width is found to increase with increasing fissility of the CN for both the cases. It has been observed from Fig. 2 (lower panel) that for energies below and well above the capture barrier, the experimental mass-width can be fitted by a linear fit.

Conclusion

The systematic trends of the mass widths have been investigated as a function of the excitation energy of the compound nucleus and the excitation and at the scission point. The mass distributions are generally much wider than equilibrium mass distributions calculated for the scission point, indicating the presence of a substantial contribution from QF. The mass widths for many of the reactions show a consistent systematic trend as a function of the bombarding energy with respect to the capture barrier, with the widest distributions at the lowest energies. Exceptions are reactions with the spherical target nuclei, where the mass widths increase monotonically with energy from the lowest measured beam energies. These systematic trends indicate that-mass distributions are very wide (showing the presence of QF and short reaction time scales).

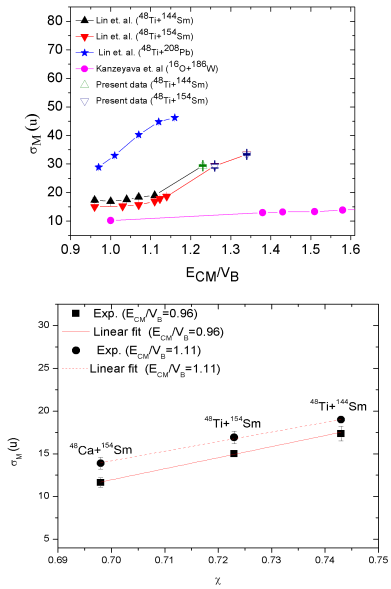

FIG. 2: The mass-widths of the fission fragments as a function of the center-of-mass energy (upper panel) with respect to the capture barrier fissility (lower panel) for each reaction.

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